



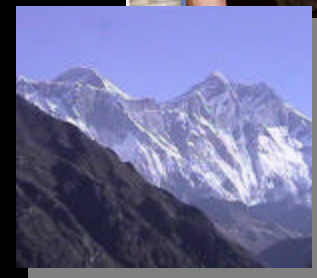
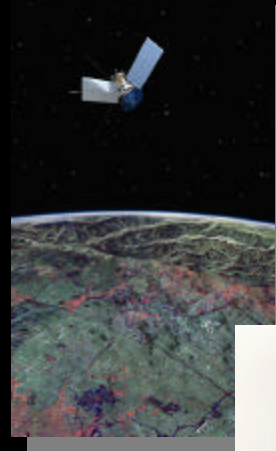
Telehealth in NASA

Arnauld E. Nicogossian, M.D.
Associate Administrator,
Office of Life & Microgravity Sciences and
Applications,
NASA

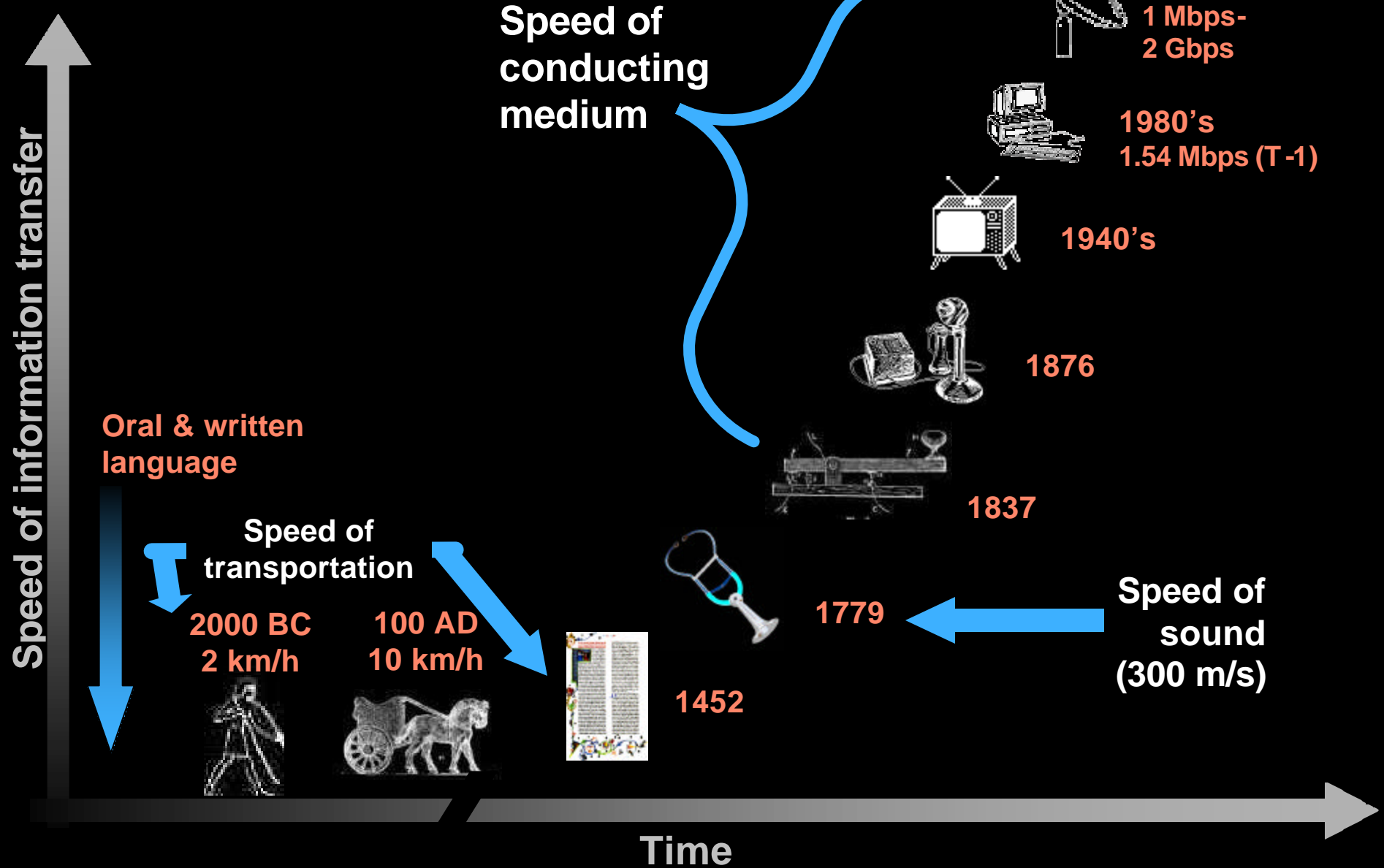


Contents

- Telehealth in perspective
 - History
 - Technology & cost
- Telehealth in NASA
 - Mission integration
 - Principles
 - Criteria & models
 - Challenges
 - Roles
 - Testbeds
 - The future
 - Hierarchy of technology
 - Outreach & application
- Conclusion



History of Communication & Telehealth



How Fast Can Data Move Today?

Telehealth

Application

Paging
512 bps-1.2
kbps

Voice
64 kbps

Videoconferencing
128 kbps-1 Mbps

Video
(MPEG)
1.54 Mbps

Hi-res
imaging
8-100 Mbps

Virtual reality
>100 Mbps

narrowband

speed

broadband

X.25
56-64 kbps

Circuit-
switched pair
64 kbps

ISDN
128 kbps

T-1 line
1.54 Mbps

Ethernet
network
10 Mbps

Satellite
transponder
12 Mbps

ATM
622 Mbps

Transmission method

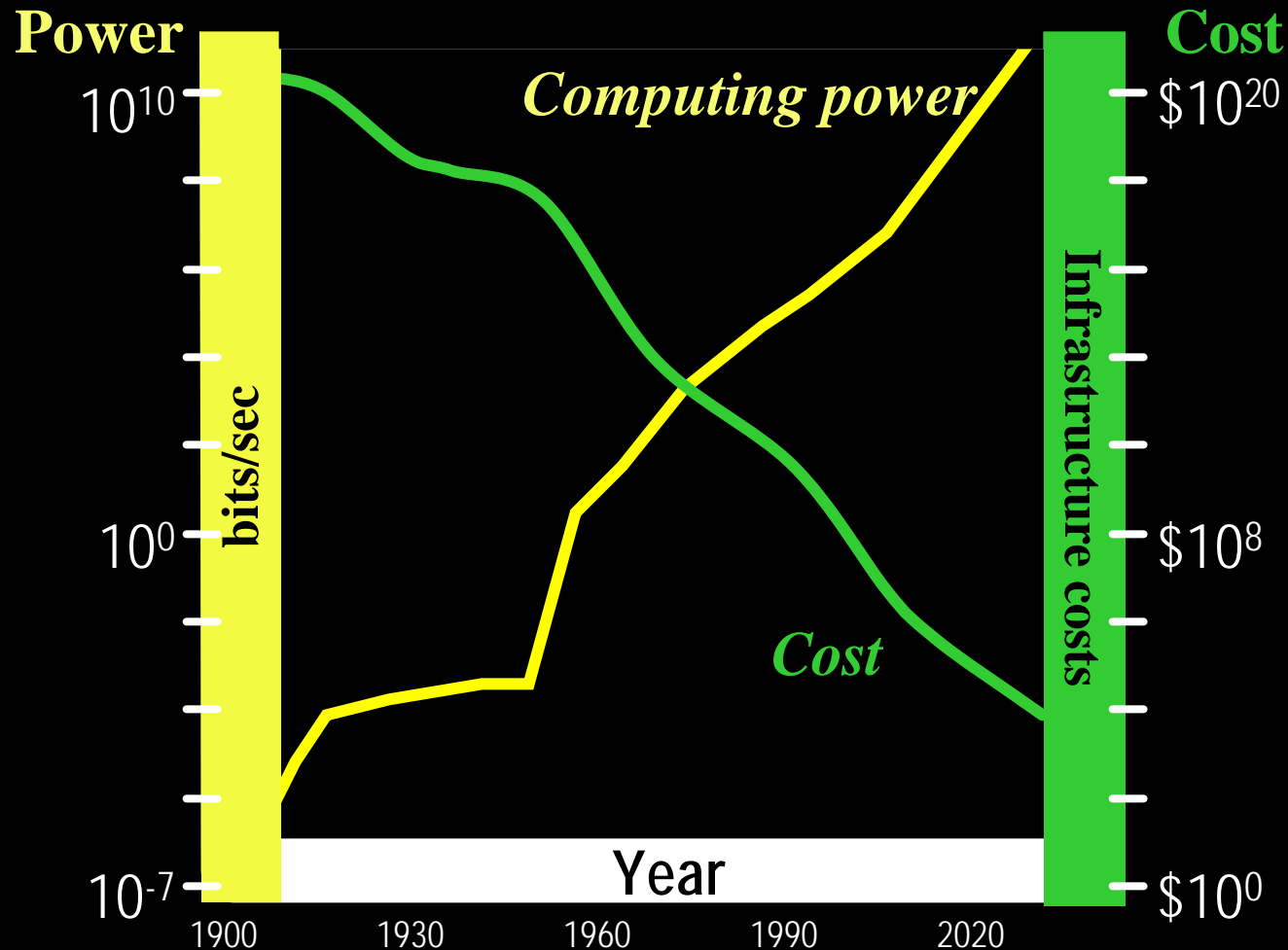
1 Gigabit (Gb) = 1,000,000,000 bits

1 Megabit (Mb) = 1,000,000 bits

1 kilobit (kb) = 1,000 bits

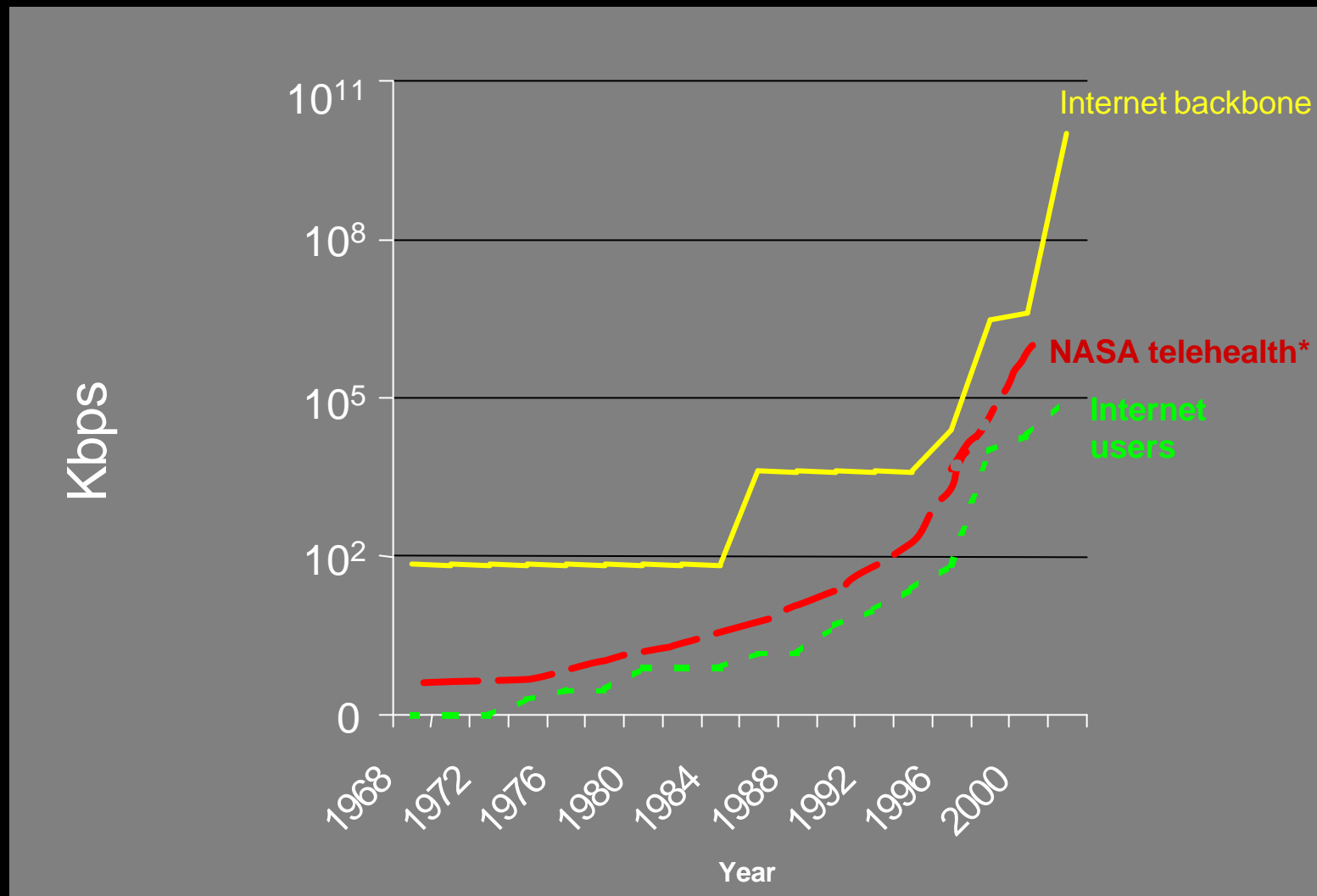
Source: Futron Corporation, 2000

Power vs. Cost of Computing



*Adapted from Hans Moravec, *Mind Children: The Future of Robot and Human Intelligence* (Cambridge, MA: Harvard University Press, 1988).

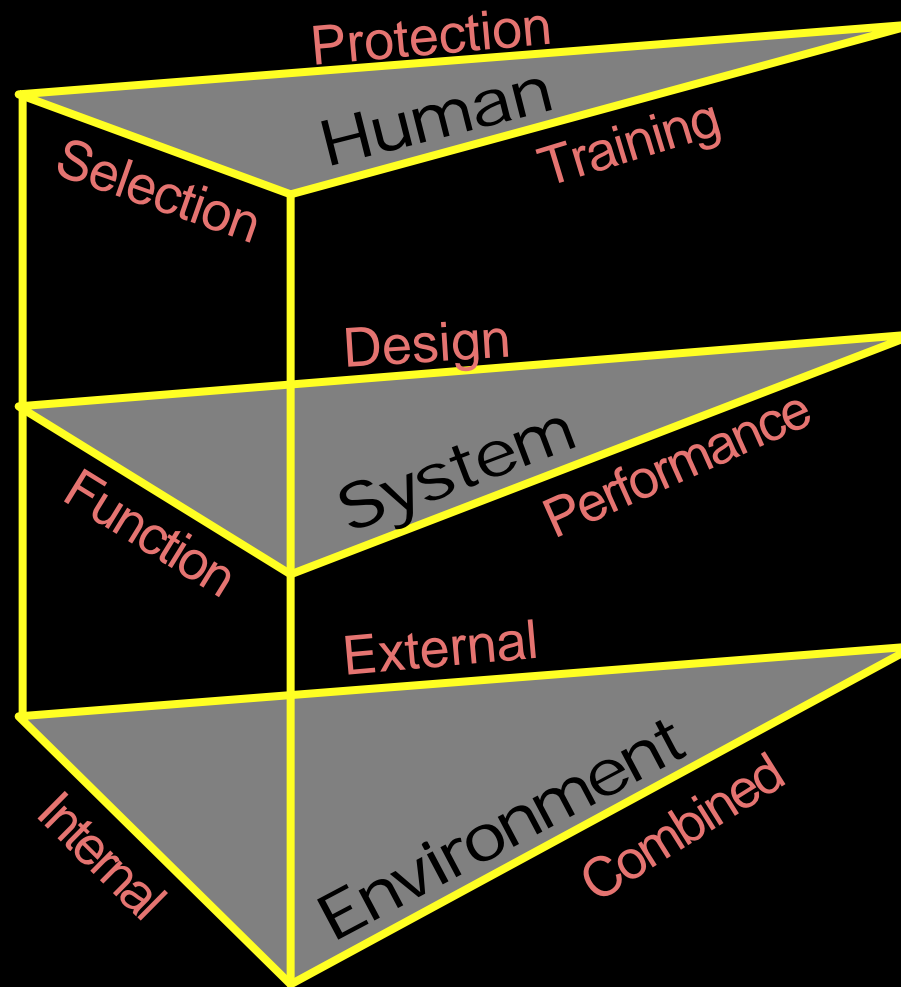
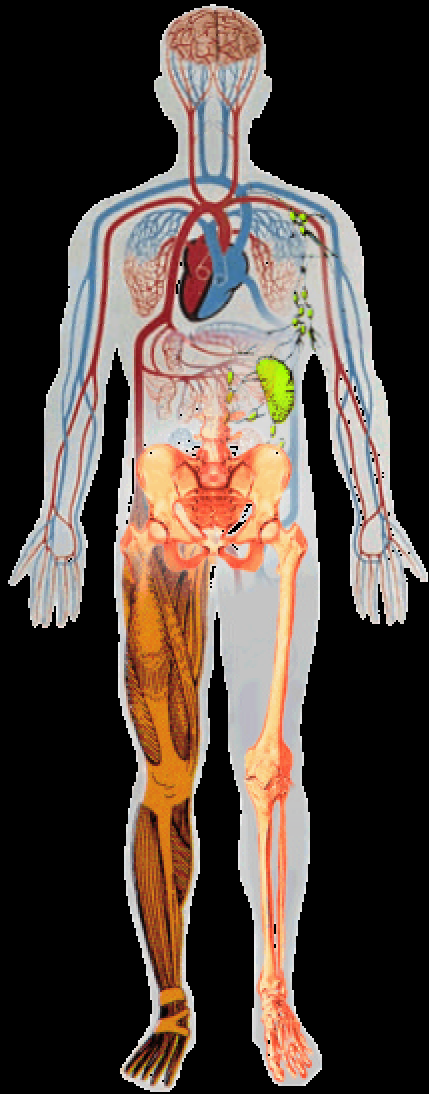
Bandwidth Demand



Adapted from Vinston Cerl, "Beyond the Millennium: The Internet,"
<http://www.mci.com/mcisearch/aboutyourinterests/technology/ontechcertreport0697.shtml>, 1997.

* Maximum bandwidth for
idea resolution

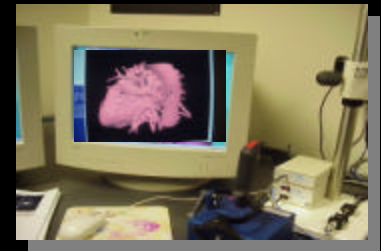
NASA Mission Integration



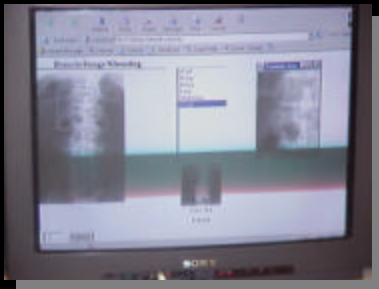
NASA Telehealth Principles



MONITOR



PREVENT



TREAT



NASA Health Criteria

- Maintain health and well-being before, during, and after missions
- Ensure rapid re-adaptation to gravitational forces

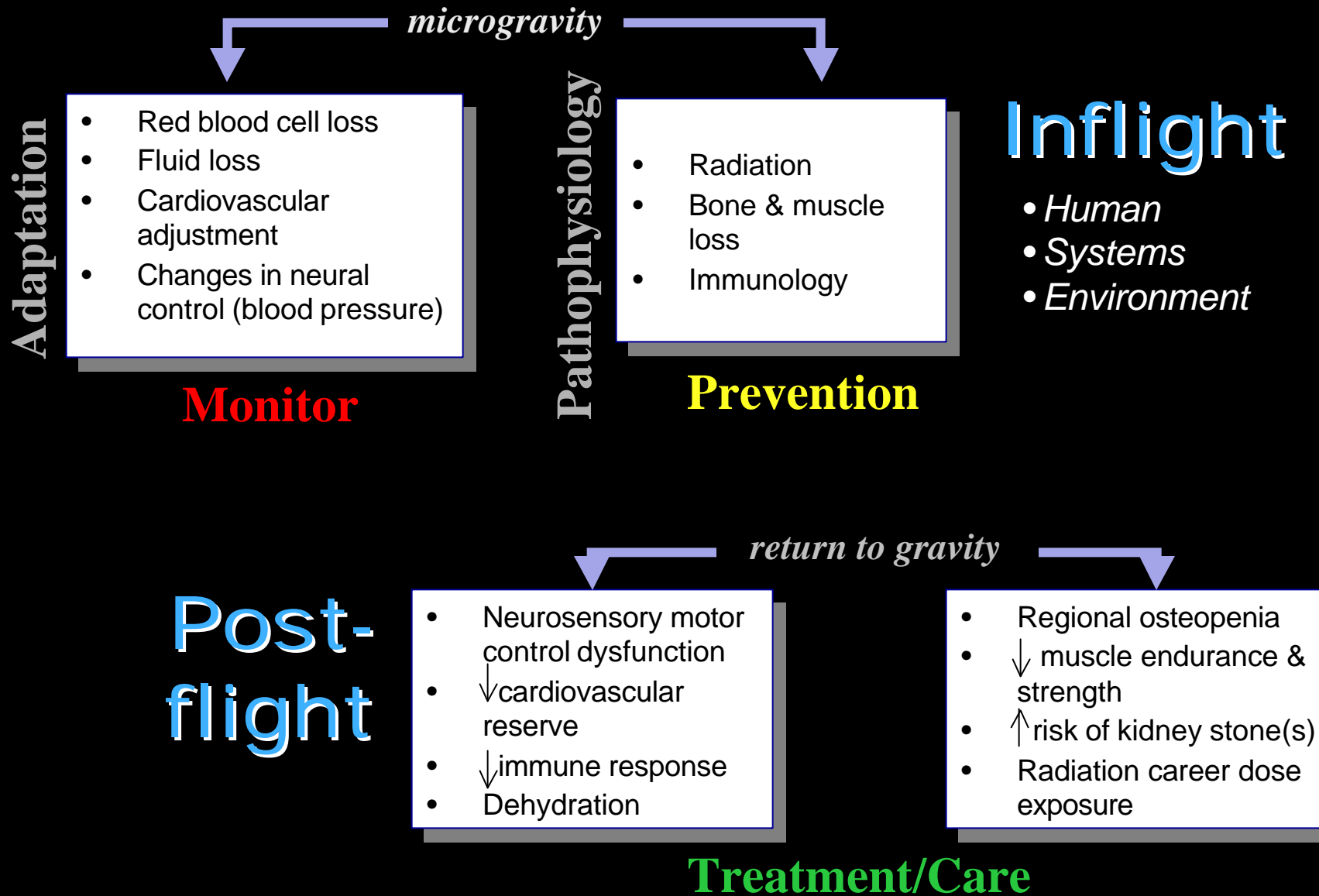


NASA Care Criteria

- Ability to treat crew members and return them to duty
- Minimize impact on remainder of crew
- Provide for stabilization and evacuation (in LEO)
- Provide for crew safety
- Provide for remote consultation



NASA Health Care Models

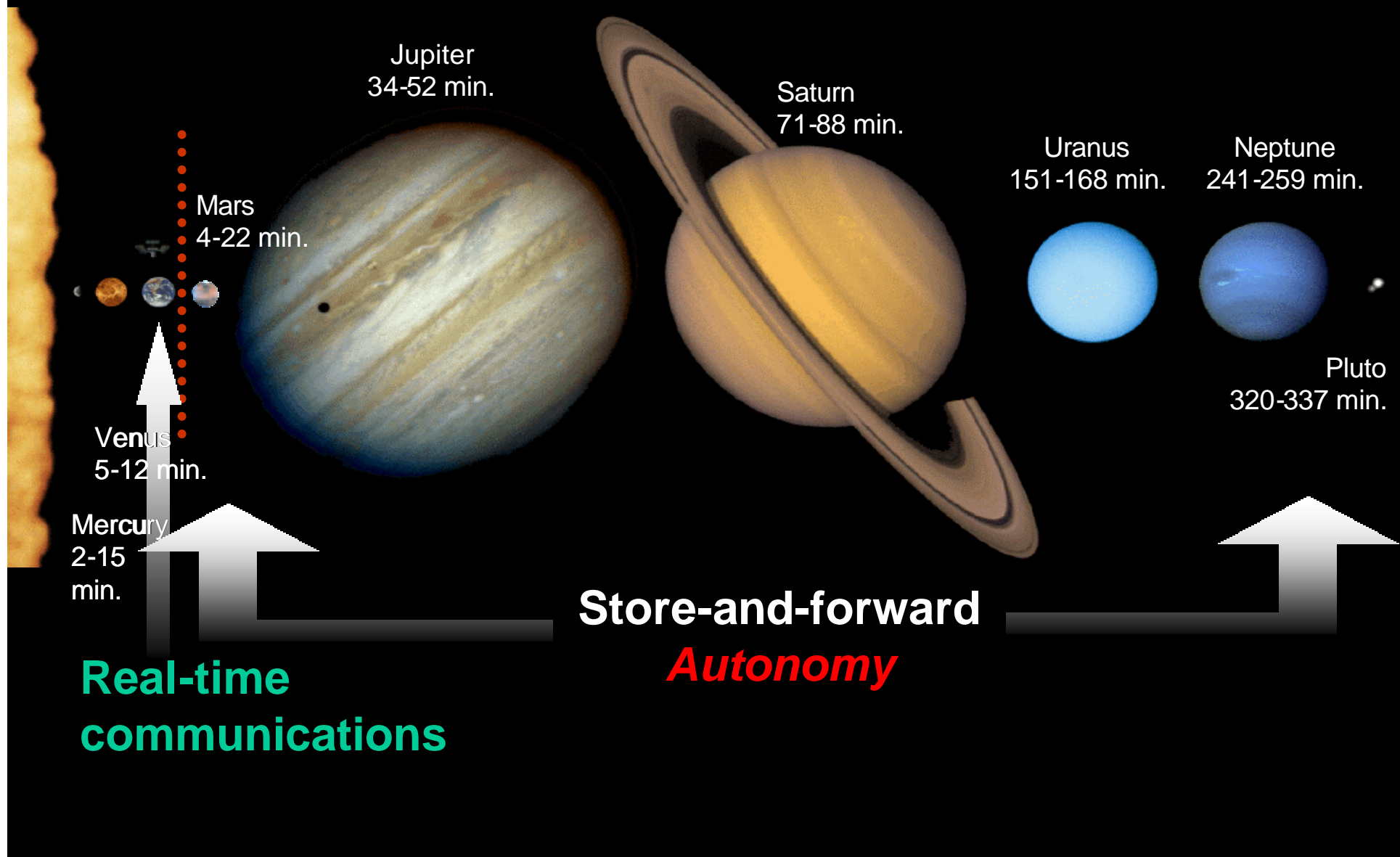


Telehealth

*Telehealth and
telescience are
essential to
NASA's
programs*



Time and Space



Telehealth in NASA

...move
bits, not
patients

Provider

SPACE

Monitoring

Imaging

Dermatology

Psychosocial
support

Education

Pharmacology

Epidemiology

Surgery

User/
Patient

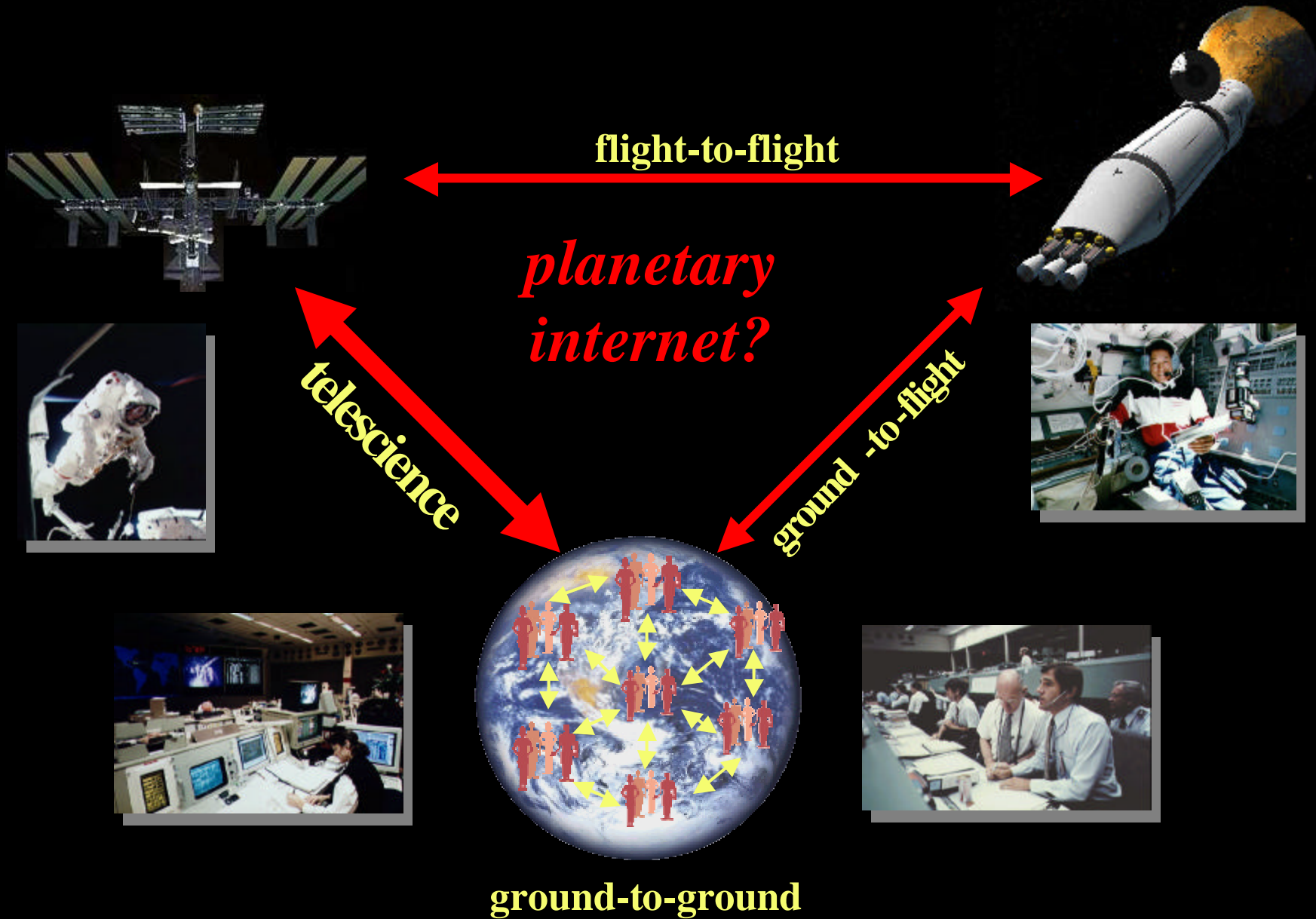
GROUND

■ current use
■ planned use

NASA Testbeds



Future Plans



Building Future Health Care Today

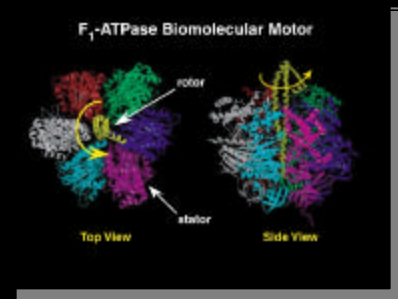
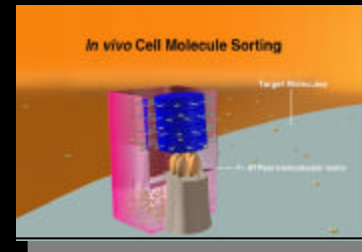
From telecare to autonomy.....?

- Adaptive automation
- Multipurpose tactile interface
- Maintaining operator alertness
- Intelligent databases
- Self- assembling nanostructures
- Tissue engineering
- Telescience
- Cognitive prostheses
- Biologically-inspired robots
- Wireless biosensors
- Medical informatics
- Smart systems
- Minimally-invasive surgery
- Cybersurgery

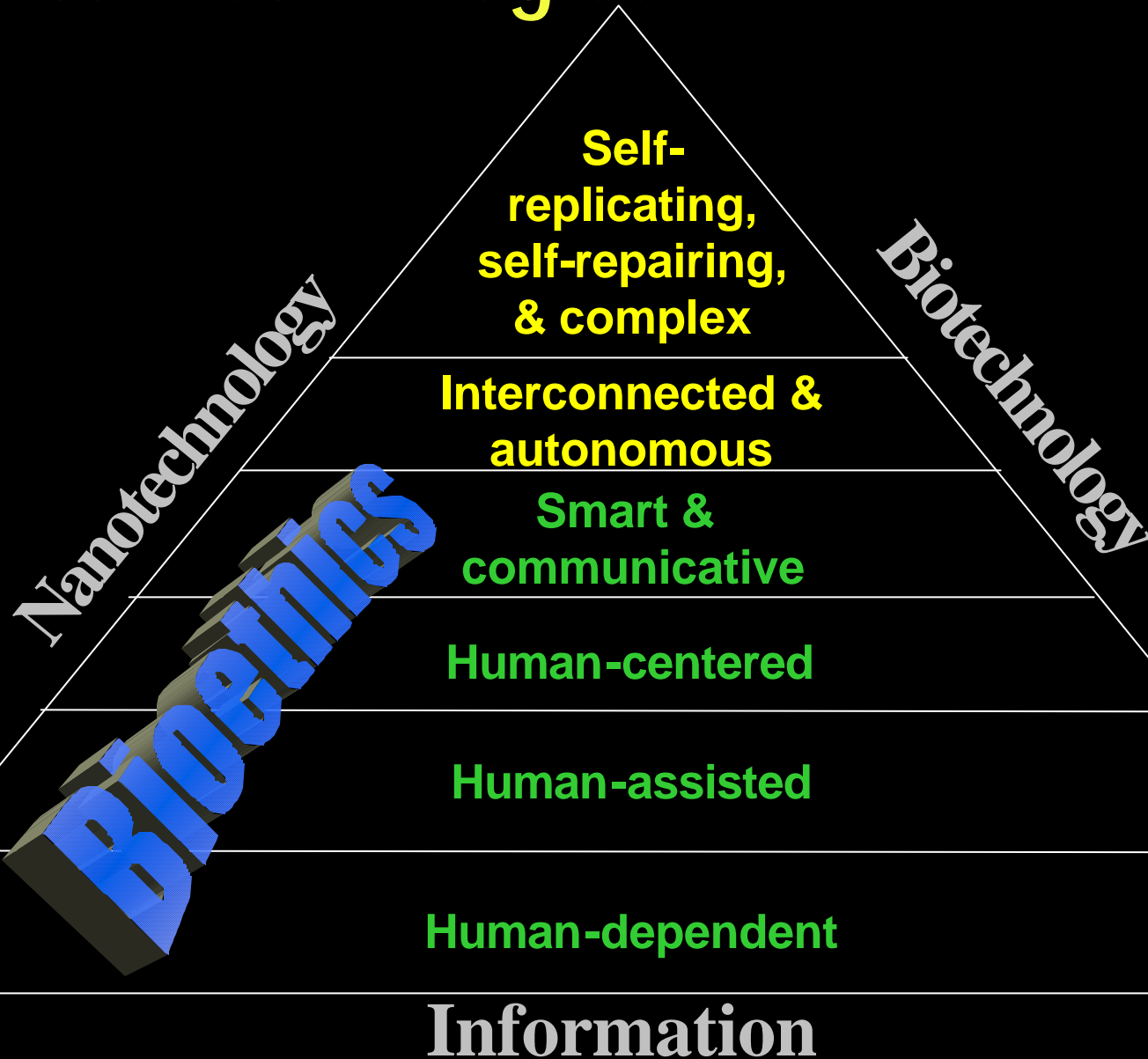


Hair cell sensors

Biomotors



Hierarchy of NASA Medical Technologies



Outreach & Applications

Collaborations between NASA centers, universities, Commercial Space Centers, and private industry ensure the widest possible distribution of telehealth technology...

Rapidly Deployable Telemedicine Systems

Kosovo, Dominican Republic, Ecuador



Pill-shaped biotransmitters



WARP

Wireless Augmented Reality Prototype

Virtual Collaborative Clinic (VCC)

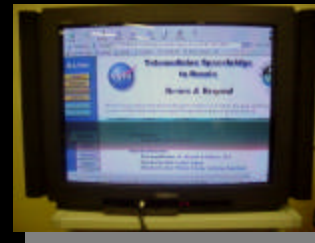
GRC, Stanford Univ.,
Salinas Valley
Memorial Hospital,
Northern Navajo
Medical Ctr., ARC



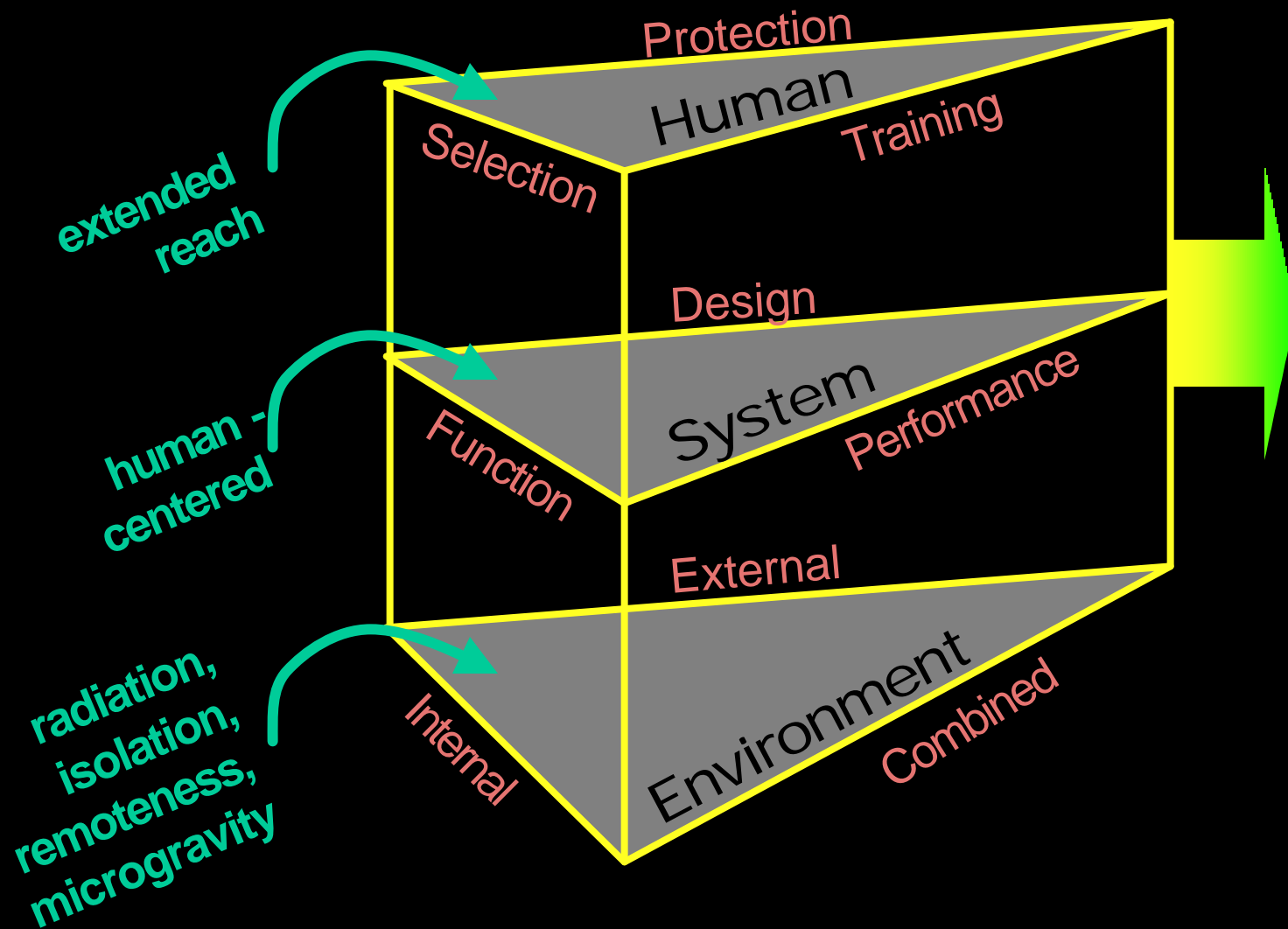
E-Nose



Telecollaboration On-Line Database



Telehealth & Exploration



EXPLORATION



Conclusion

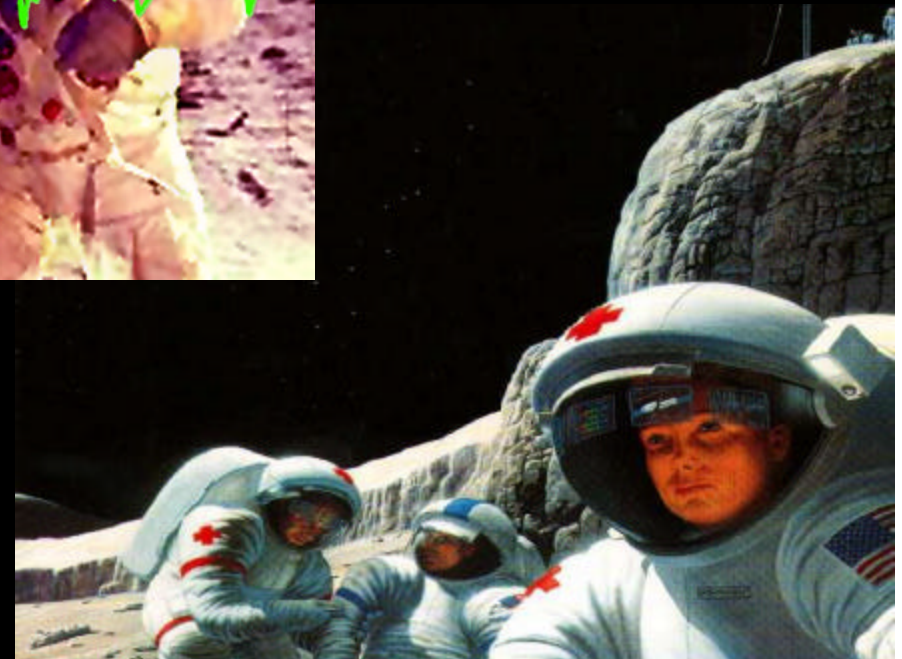


1924

1969



2000+



“ When the pace of events and their variety make it more difficult to predict what will happen next week or next month, it is even more important to be oriented toward the long term.....”

President Bill Clinton, 1998



Backup

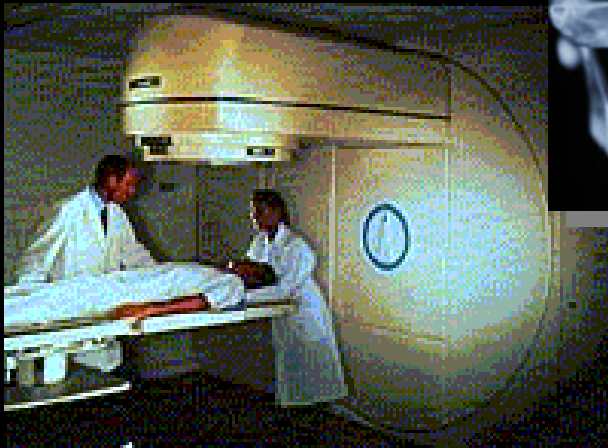
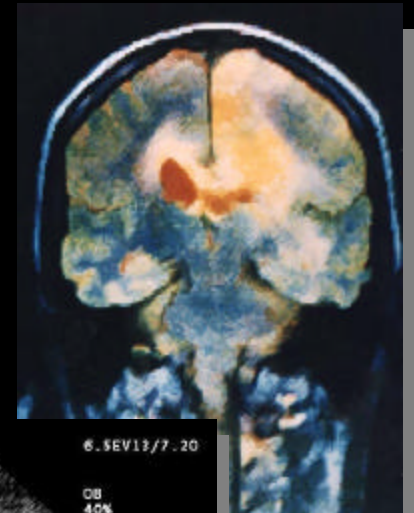
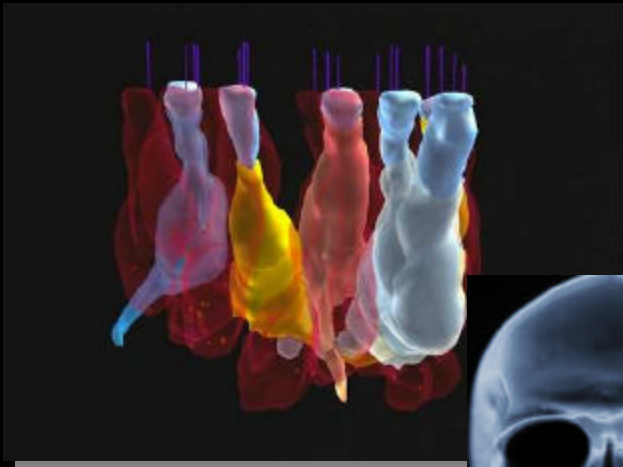
Telehealth Requirements

- Improve traditional tools
- Minimize geographic inequality
- Enhance the quality of care
- Contain expenditure/infrastructure cost



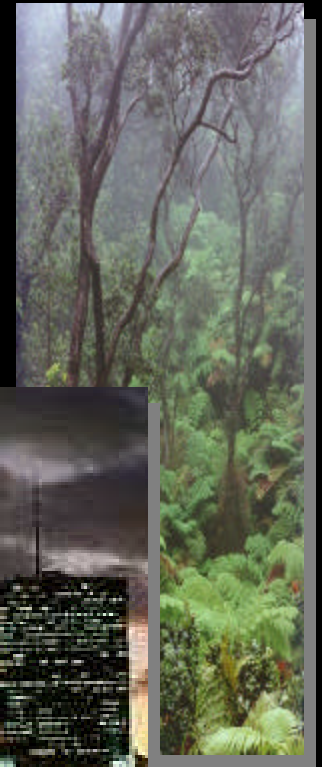
Telehealth Requirements

Improve traditional tools



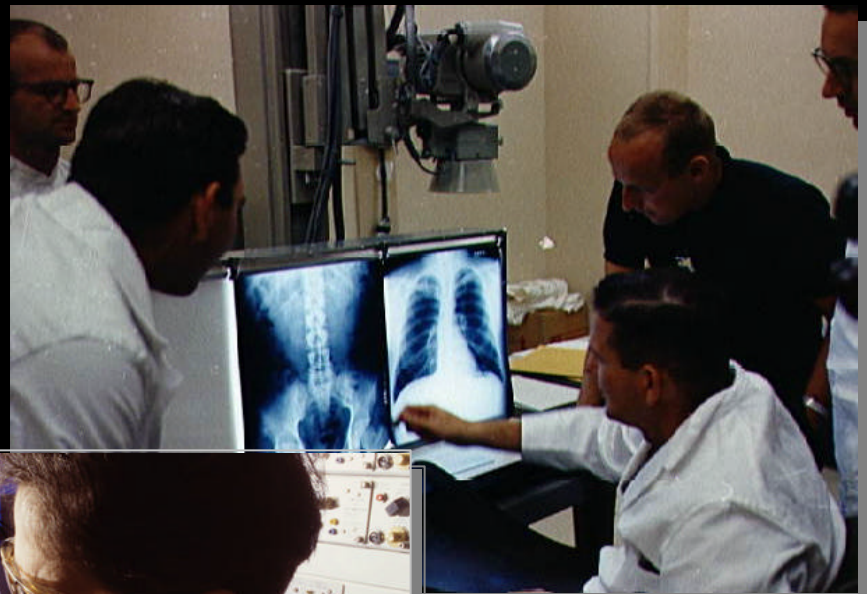
Telehealth Requirements

Minimize geographic inequality



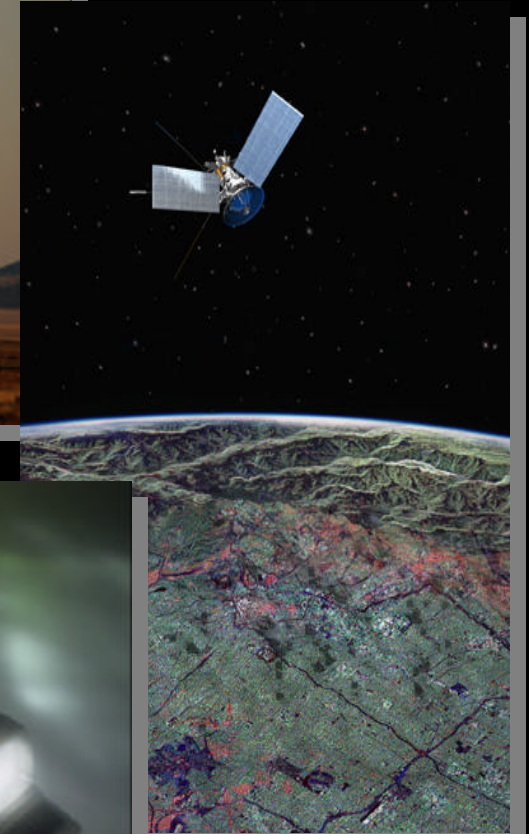
Telehealth Requirements

Enhance the quality of care



Telehealth Requirements

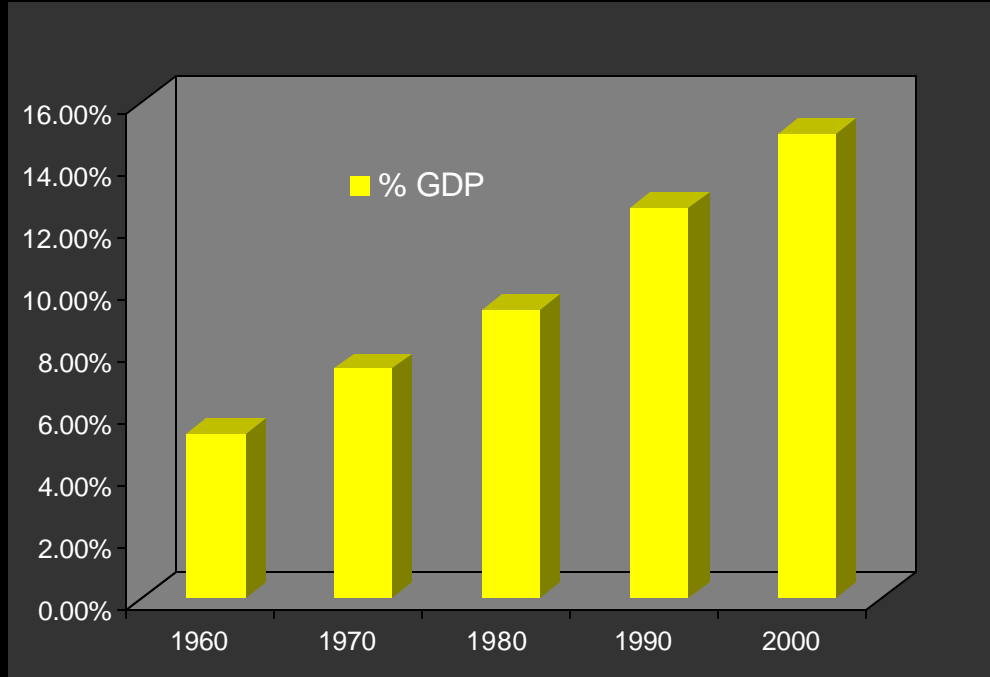
End-user infrastructure



Telehealth Requirements



**Contain expenditure costs & reduction
of infrastructure barriers**



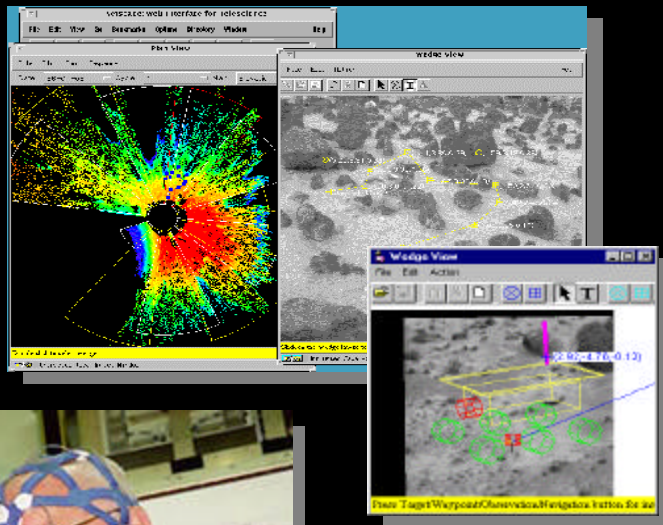
**Historical U.S. Healthcare
Expenditures**

- Barriers
 - Security
 - Insurance reimbursement
 - Medical licensure across states
 - Technology (bandwidth)

Telehealth Requirements



Applications



U.S. Telehealth: the Civil Sector

- Applications
 - EMS/rescue
 - Education (“Dot-Com” companies)
 - Teleimaging
 - Outpatient care/ home care
 - Maritime telecare
 - Prison telemedicine
 - Automated patient record systems
 - Disaster relief/humanitarian efforts
- Barriers
 - Security
 - Insurance reimbursement/liability
 - Medical licensure (across states)
 - Technology (bandwidth)



U.S. Telehealth: Dept. of Defense

- 1976: digital tooth
- 1985: digital x-rays
- 1990's: telepathology
- 1990's: teledermatology
- TATRIC (Army/NASA)
- Maritime telehealth (Navy)
- Deployments
 - Bosnia
 - Somalia
 - Persian Gulf
- Disaster relief



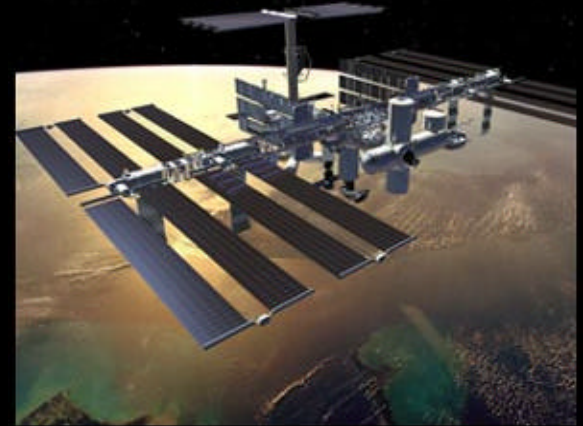
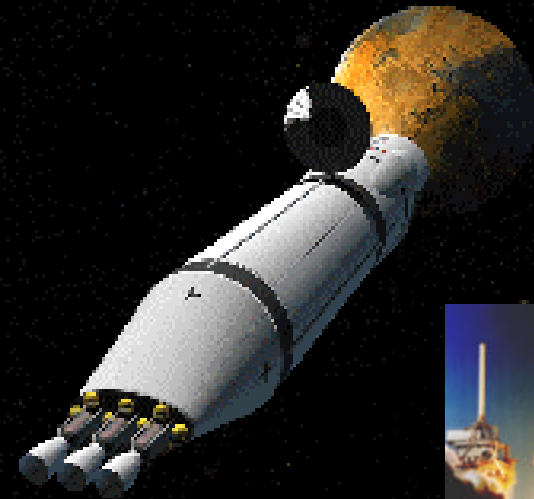
Lessons Learned from the DoD

- Telehealth works best with...
 - Full-time support
 - Reliable, mobile, user-friendly communications
 - Easy coordination
 - Information security
- Future considerations
 - Changes in health care patterns
 - Medical business reengineering
 - New technology



NASA Telehealth Applications

- 1961-1972
 - Monitoring
 - Automation
 - Minimal command
- 1981-present
 - Telemonitoring
 - Teleimaging
 - Telescience
- 2000+
 - Telemonitoring
 - Teleimaging
 - Telescience
 - Teleconsultation
 - Telecare
 - Telediagnosis



NASA Telehealth Applications



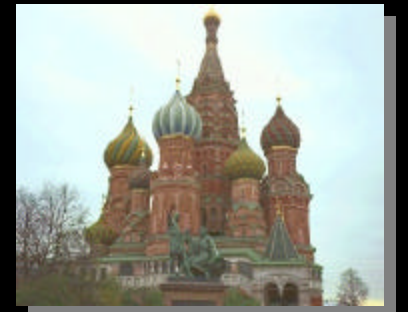
- 1972-3
 - ✓ STARPAHC
- 1975
 - ✓ Applied Technology Satellite
 - ✓ COSPAS/SARSAT
 - ✓ PEACESAT



- 1985
 - ✓ Mexico City earthquake
- 1989
 - ✓ Spacebridge to Armenia/Ufa



- 1993
 - ✓ ACTS demonstrations
 - ✓ Spacebridge to Moscow
- 1994
 - ✓ GHNet (WHO/USAID)
 - ✓ Pan-American Health Organization (PAHO)
 - ✓ Spacebridge to Russia (through 1997)



✓ completed

NASA Telehealth Applications

- **1995**
 - ✓ ARC telemed demo with Trident & Mt. Sinai Medical Center
- **1997**
 - NASA-MITAC established
 - East-West Space Science Training Center
- **1998**
 - ✓ Ecuador “keyhole” surgery
 - ✓ Everest Extreme Expedition I
- **1999**
 - ✓ Virtual Hospital demo with ARC, Stanford, Salinas
 - ✓ Everest Extreme Expedition II
 - ✓ TIP demonstration in Texas and Montana
- **2000**
 - Low-bandwidth telemonitoring in Ecuador
 - Low bandwidth telemonitoring in Dominican Republic
 - Kosovo disaster response
 - Devon Island telemedicine



NASA's Health Criteria

Medical standards are tailored to meet the specific needs of each class: pilot (I), mission specialist (II), or payload specialist (III).

Evaluation approach

- Selection criteria
 - Medical history and physical
 - Lab & functional testing
- Retention criteria
 - Health maintenance
 - Acceptance of certain risks with changes

Areas of Emphasis

- Short-duration mission
 - Neurosensory
 - Neuromotor
 - Cardiovascular/ cardiopulmonary
 - Fluid & electrolyte
- All missions
 - Performance
 - Psychosocial suitability
 - Survival
- Long-duration mission
 - All short-duration concerns
 - Musculoskeletal
 - Radiation exposure
 - Metabolic/endocrine
 - Hematology/immunology

A Comparison: Who Does What?

Tele-imaging

Telecare/Telediagnosis

Telepathology

Telecardiology

Teledermatology

Tele-education

Teleconsultation

Telemonitoring

Humans

Systems

Environment

Telescience

Testbeds

NASA	Civil Sector	DoD
✓	✓	✓
✓	✓	✓
✓	✓	✓
✓	✓	✓
✓	✓	✓
✓	✓	✓
✓	✓	✓
✓	✓	✓
✓	✓	✓
✓		
✓		
✓		
✓		
✓	✓	✓

NASA Telehealth



The **first generation** of NASA telehealth provided for Earth-based monitoring of survivability in space.



The **next generation** will allow us to expand and extend the human reach into space, while preparing us for bold future missions that couple robotic and human explorations.

